# GAMBREL ROOF BRACED RAFTERS

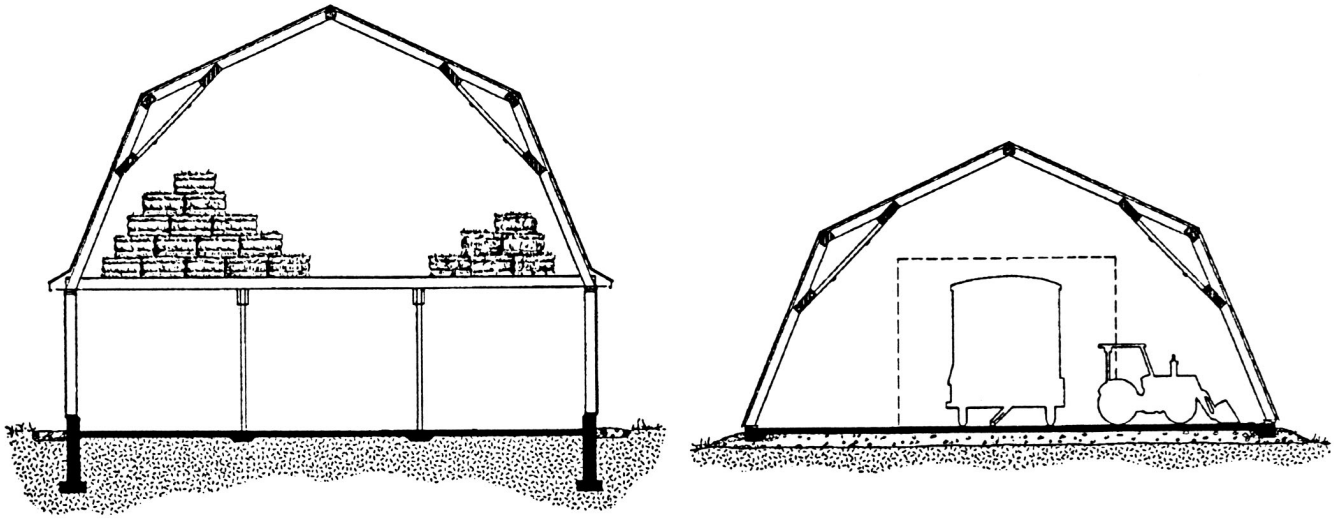


**FIGURE 1**

**CPS**
**PLAN M-9250**

H.A. JACKSON, D.I. MASSÉ

This leaflet gives a listing of 15 designs in metric/imperial dimensions for gambrel roof braced rafters which can be easily assembled on the farm or in a prefabricating plant.

The gambrel roof form (Figure 1) has retained its popularity with farmers and builders for several good reasons:

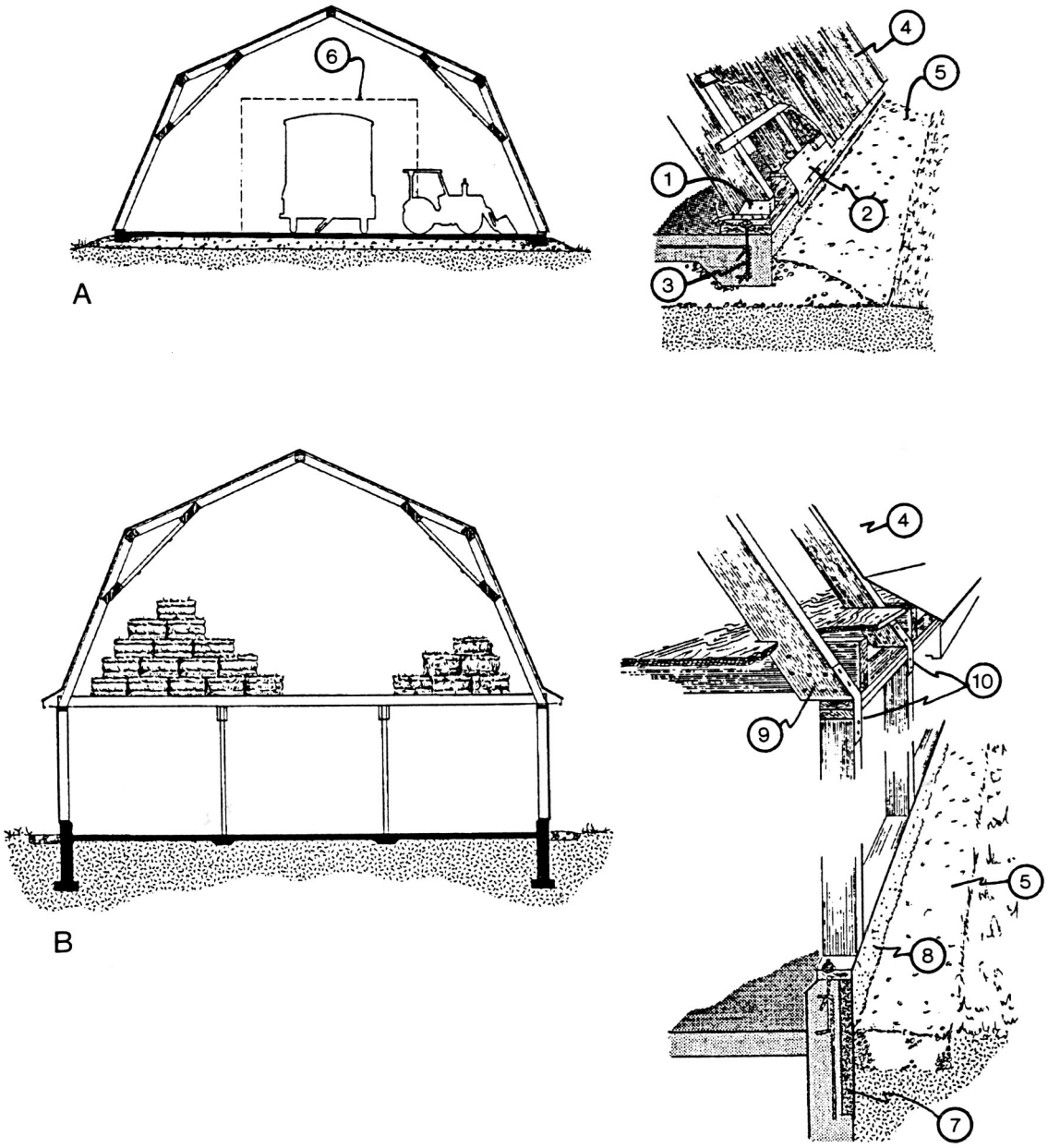
- simple, efficient design, framed with only four main members
- attractive, traditional roof
- clear span storage space without interior columns

Canada Plan Service braced rafters are designed for 'dry' service conditions, for wind and snow loads on low human occupancy (LHO) farm buildings (0.8 importance factor) as defined in the Canadian Farm Building Code. LHO farm buildings include most farm buildings except processing rooms, auction and show arenas etc. where larger numbers of people might be assembled for significant time periods.

Figure 2 shows typical farm applications for braced rafters. Figure 2a shows the gambrel roof form used for a machinery storage, with an inexpensive floating slab foundation system suitable for well-drained granular soil where frost heave is not a problem. In western Canada where frost penetrates to great depths, experience indicates this foundation may be 'floated' on a deeper fill of compacted gravel which provides drainage and protection from frost heave.

Figure 2b show the traditional use of the braced rafter.

DEVELOPED BY CANADA PLAN SERVICE




1 Joist hangars, galvanized roofing nails
2 Steel rodent flashing, nailed to rafters and sill
3 Anchor bolts tied to foundation and floor rebars
4 Roofing
5 Gravel
6 Endwall doorway, size limited only by ceiling line
7 Polystyrene perimeter insulation
8 High-density asbestos board
9 Rafters nailed to floor joists
10 Steel strap ties, nailed to rafters and studs

**FIGURE 2 Ways to use gambrel roof braced rafters**

Be careful to ensure that the braced rafters are fastened to the building at their bases to resist the horizontal and vertical forces at these locations due to roof loads (snow, rain, wind and dead weight). These forces are tabled on the plan sheet. The walls and foundation must be designed to resist these forces, otherwise the walls and footings can be pushed outwards or pulled up resulting in collapse of the building.

Table 1 lists the Canada Plan Service braced rafters. Each plan sheet gives safe snow (ground snow plus rain) and wind load capacities for each braced rafter when spaced at 600 mm (24 inches) on centre.

**BRACED RAFTER FABRICATION**

Canada Plan Service braced rafters are fastened with double plywood gussets nailed from both sides. Nails are common spiral nails 64 mm (2 1/2 inches) long and they penetrate the plywood gussets on both sides of the rafters. To assemble, lay out the first arch carefully and add blocking at critical points to make an assembly jig supported solidly for effective nailing. Then assemble each subsequent arch in 3 layers (gussets, frame, top gussets) and nail in the assembly jig. Then remove the arch, turn it over, and drive the second set of nails from the other side. Truss prefabricators may prefer to use metal press-plates instead of plywood gussets and nails; in this case the braced rafter designs will have to be altered and guaranteed by the prefabricator.

**BRACED RAFTER ERECTION AND BRACING**

A braced rafter roof system, properly designed, fabricated, erected and braced, is a strong and economical way to frame a farm building roof.

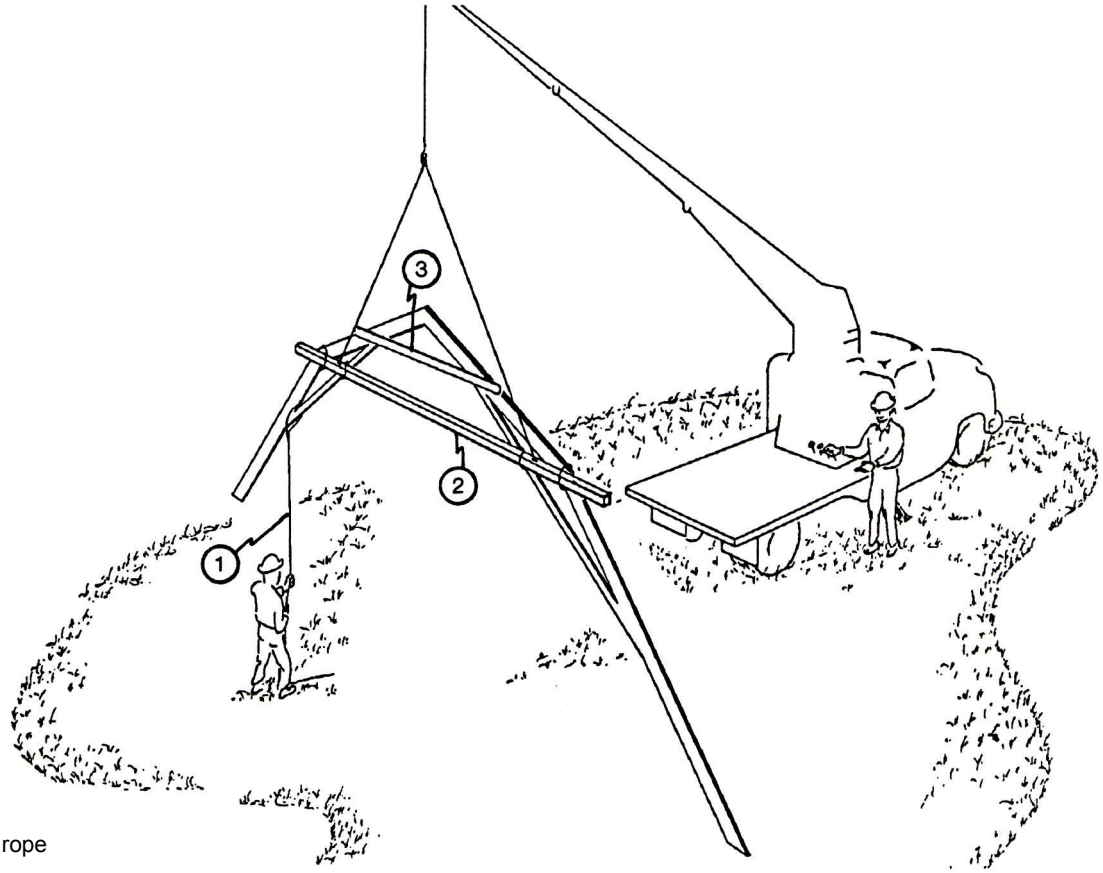
However, if the design assumptions are ignored during erection and bracing, the structure may collapse.

Individual braced rafters may fail if damaged during transport or erection. The following points outline procedures and precautions recommended to ensure safe braced rafter erection:

- Braced rafters have very little strength in the lateral direction; when handling, take extreme care to avoid damaging the braced rafters or overstressing the wooden members and the connections. The ridge connection is very susceptible to damage until the braced rafter is erected and braced: it should be reinforced with a temporary brace (Figure 3).

- Plan and mark the locations of the roof purlins while the braced rafters are stacked on the ground.

- Erect braced rafters by lifting them with a crane and strongback; the strongback may be any stiff material such as pipe, steel beam or heavy timber. Clamp or tie the strongback to each braced rafter at points not over 2.4 m (8 ft) apart, and above the mid-height of the braced rafter to prevent overturning. Attach a rope to the braced rafter to guide it into position from ground level (Figure 3)




1 Guide rope

2 Strongback approx. 2/3 to 3/4 of braced rafter span

3 Temporary erection brace

**FIGURE 3**

- Position the first braced rafter at one end of the building and brace it to the ground or lift and anchor to the second story floor of a two story barn. These temporary braces must support the braced rafter against wind from either direction (Figure 4).

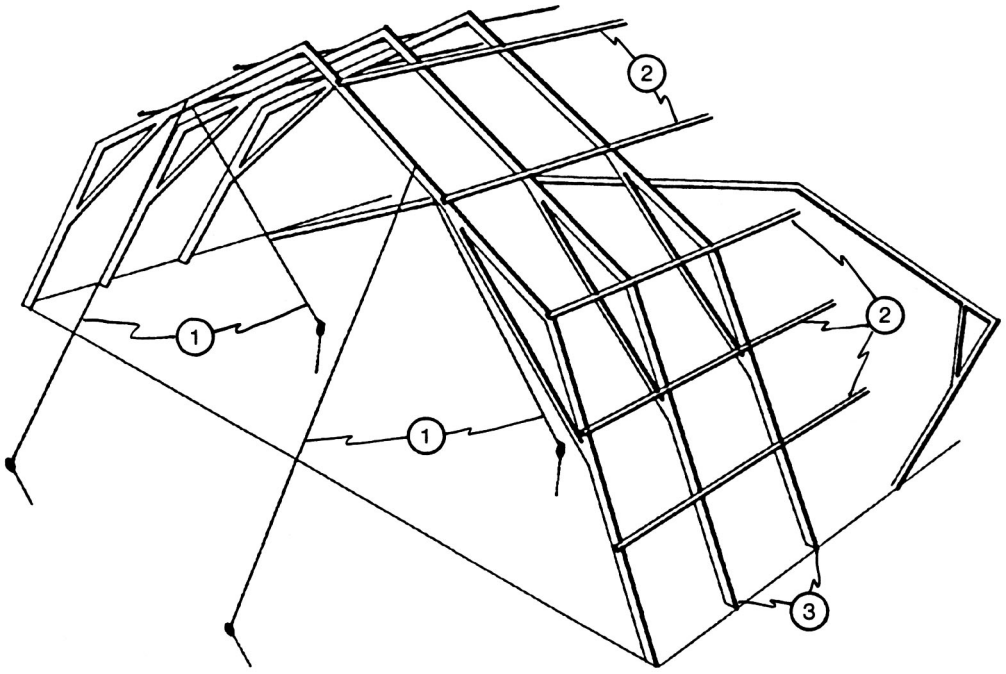
- As each braced rafter is positioned, fasten both ends permanently to the existing structure or foundation with metal straps, framing anchors, or bolts. Toe nailing is not adequate. Be careful to ensure that this connection is strong enough to resist the horizontal and vertical forces (snow, wind and dead weight) from the braced rafter. These forces are tabled on the braced rafter plan. Also ensure that the existing structure can resist these braced rafter forces. If these forces are not adequately resisted, the building will collapse.

- Position the second braced rafter, spacing it from the first one with short 2.4 m (8 ft) purlins (Figure 4). These first purlins will later alternate with 4.8 m (16 ft) purlins to stagger the end joints. These first purlins are very important because they provide lateral support to rafters which are susceptible to lateral buckling if not properly braced, even if the braced rafters are only supporting their own weight.

- Set the third braced rafter into position and fasten it to the first two with the first short purlins. Then set the fourth braced rafter into position and fasten it to the previous braced rafters with long 4.8 m (16 ft) purlins alternating between the short ones. Fasten all subsequent braced rafters with long purlins. This sequence is illustrated in Figure 5. As soon as four or five braced rafters are erected and braced with purlins, install some roof sheathing. If you can't do this yet, add temporary cross-bracing on top of the purlins (Figure 5) at the end of the building to prevent S-buckling of all braced rafters together. At the same time, install the lateral supports and cross-bracing for the rafter bracing described in the next step and illustrated in Figure 6.

- The braced rafter design engineer is responsible to check for possible buckling of the rafter braces. The engineering drawings specify wherever stiffeners are required for lateral support. There is still a possibility that all rafter braces could buckle in the same direction, so permanent cross-braces should be fastened to the longitudinal stiffeners at each end of the building (Figure 6).

- If the braced rafters are not sheathed on the interior, it is recommended that permanent cross-bracing be installed on the underside of the rafters at both ends of the building (Figure 7). In longer buildings, this permanent cross-bracing should be repeated at approximately 30 m (100 ft) intervals as well.

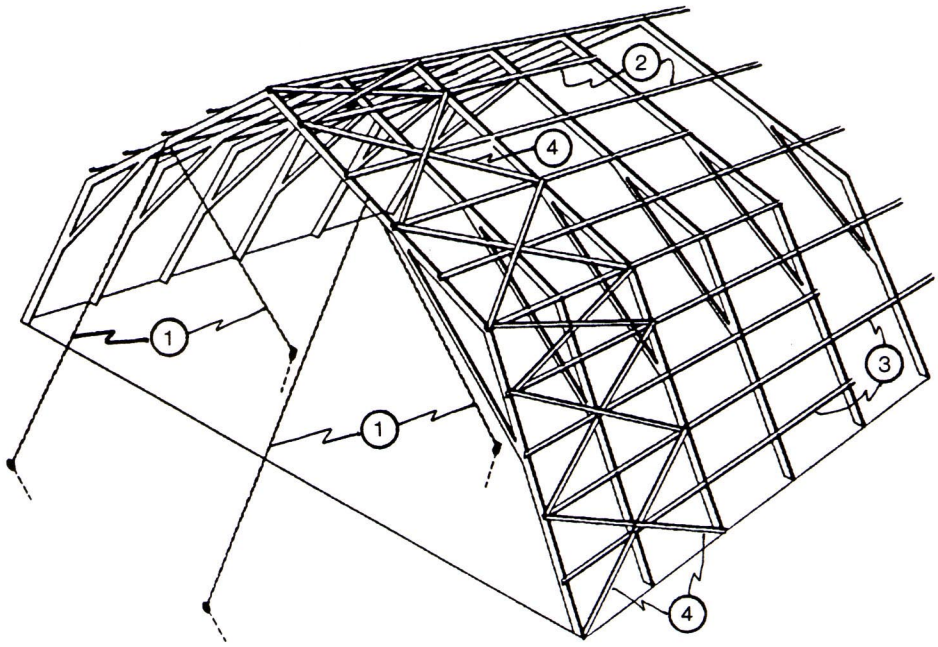



1 Temporary cable bracing at endwall.

2 Rafter to rafter bracing, purlins or temporary bracing, 1200 mm (4'-0") max.

3 Attach ends of rafters permanently to plate or sill with metal framing anchors or equivalent. Toe nailing is not adequate.

**FIGURE 4**



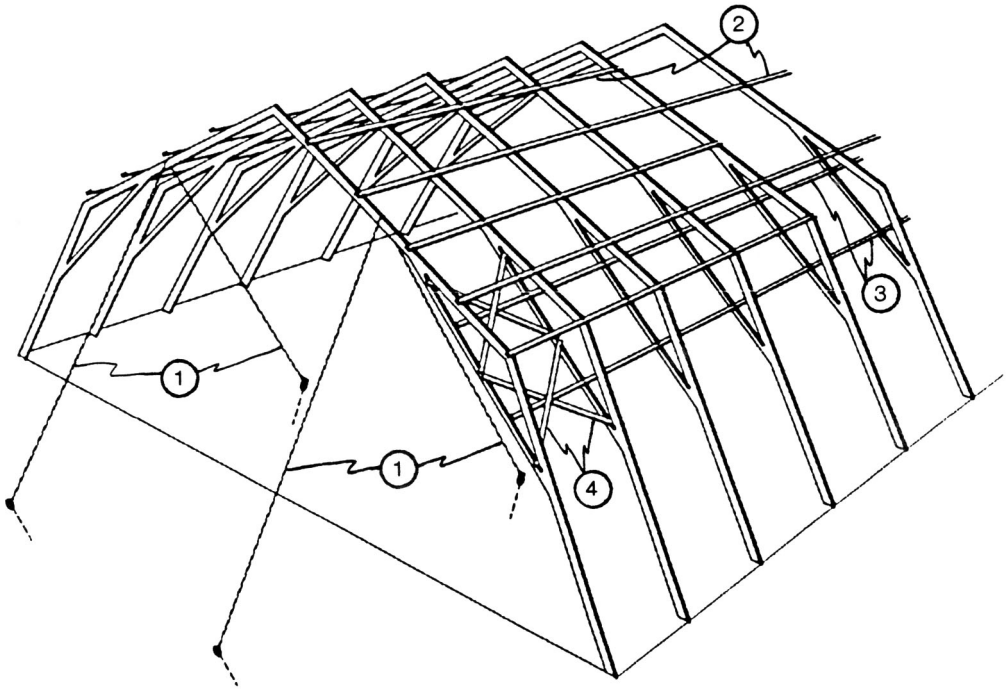

1 Temporary cable bracing at endwall.

2 Rafter to rafter bracing, purlins or temporary bracing, as in Fig. 4

3 Permanent bracing of rafters with purlins, 600 mm (2'-0") max.

4 Start roofing to prevent buckling of rafters or add temporary cross-bracing to top of purlins. Remove after roofing is started.

**FIGURE 5**



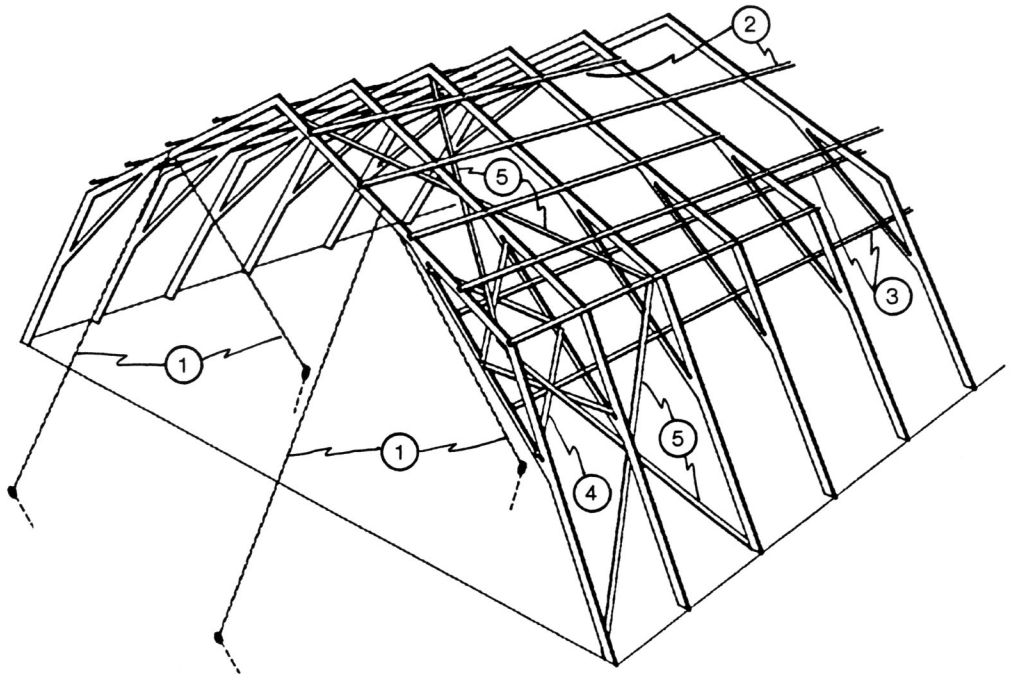

1 Temporary cable bracing at endwall.

2 Rafter to rafter bracing, purlins or temporary bracing.

3 Longitudinal stiffeners for brace, see rafter plan.

4 Cross-bracing, 38 x 89 mm (2 x 4) typical, to prevent S-buckling.

**FIGURE 6**




1 Temporary cable bracing at endwall.

2 Rafter to rafter bracing, purlins or temporary bracing.

3 Longitudinal stiffeners for brace, see rafter plan.

4 Cross-bracing, 38 x 89 mm (2 x 4) typical, to prevent S-buckling

5 Interior sheathing or cross-bracing, 38 x 89 mm (2 x 4), permits removal of 1 (roof sheathing or Figure 5 temporary cross-bracing is not shown, but is also required).

**FIGURE 7**

- Do not use the braced rafters as a working platform until they are permanently braced. Never overload braced rafters by applying concentrated loads such as a pile of roof sheathing or shingles, in one spot.

- Never leave the building site without all temporary and permanent bracing properly installed.

**EXAMPLE**

Select a braced rafter for a 7.2 m (24') span low human occupancy farm building at Belleville, Ontario. Assume that the building will not be subjected to sliding or drifting snow from adjacent structures or obstructions.

For Belleville, Ontario, the Supplement to the National Building Code of Canada 1990 provides the following design information:

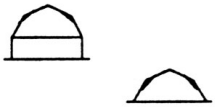
| | |
|---|---|
| ground snow load | 1.60 kPa |
| rain load associated with ground snow | 0.40 kPa |
| 1/10 hourly wind pressure | 0.32 kPa |

By adding the ground snow load and rain load components together, an unfactored snow load value of 2.00 kPa is obtained. Using this value and the 1/10 hourly wind pressure value, one can select a braced rafter from Table 1 as follows:

A. For non-slippery roofs, the 7.2 m (24') medium duty braced rafter plan M-9252 is required (max. snow 3.54 kPa, max. wind 0.97 kPa). The light duty rafter is not adequate because it's non-slippery roof snow load capacity of 1.61 kPa is less than the 2.00 kPa snow load capacity required for Belleville. The wind load capacity of 0.97 kPa for the medium duty braced rafter is adequate because it is greater than the 0.32 kPa wind load capacity required for Belleville.

B. For slippery roofs, the 7.2 m (24') light duty braced rafter M-9251 is satisfactory for a two story building (max. snow 2.46 kPa, max. wind 0.44 kPa) but not for a single story building. For a single story slippery roof building, the light duty braced rafter M-9251 is not adequate because it's slippery roof snow load capacity of 1.92 kPa is less than the 2.00 kPa snow load capacity required for Belleville. For the single story slippery roof building, the medium duty braced rafter M-9252 is required. The wind load capacity for both the light duty (0.44 kPa) and the medium duty (0.97 kPa) are adequate because they are greater than the 0.32 kPa wind load capacity required for Belleville.

**TABLE 1 CPS GAMBREL ROOF BRACED RAFTERS, 1992 SERIES**

| | | | Non-Slippery Roof | Slippery Roof | | |
|---|---|---|---|---|---|---|
| | | |  |  | |  |
| | | | Max. Unfactored Snow Load (Ground Snow + Rain) (kPa) | | | Max Unfactored Wind Load (kPa) |
| M-9251 | 7.2 m (24') | Light Duty | 1.61 | 2.46 | 1.92 | 0.44 |
| M-9252 | 7.2 m (24') | Medium Duty | 3.54 | 5.83 | 4.09 | 0.97 |
| M-9253 | 7.2 m (24') | Heavy Duty | 5.44 | 8.98 | 6.12 | 1.43 |
| M-9254 | 9.0 m (30') | Light Duty | 2.09 | 3.36 | 2.54 | 0.67 |
| M-9255 | 9.0 m (30') | Medium Duty | 3.21 | 5.34 | 3.83 | 0.99 |
| M-9256 | 9.0 m (30') | Heavy Duty | 4.97 | 8.33 | 5.78 | 1.48 |
| M-9257 | 10.8 m (36') | Light Duty | 1.40 | 1.70 | 1.70 | 0.47 |
| M-9258 | 10.8 m (36') | Medium Duty | 2.21 | 2.91 | 2.91 | 0.67 |
| M-9259 | 10.8 m (36') | Heavy Duty | 3.44 | 4.73 | 4.73 | 0.98 |
| M-9260 | 11.4 m (38') | Light Duty | 1.21 | 1.65 | 1.65 | 0.44 |
| M-9261 | 11.4 m (38') | Medium Duty | 1.89 | 2.72 | 2.72 | 0.67 |
| M-9262 | 11.4 m (38') | Heavy Duty | 2.91 | 4.39 | 4.39 | 0.99 |
| M-9263 | 13.2 m (44') | Light Duty | 1.33 | 1.84 | 1.84 | 0.50 |
| M-9264 | 13.2 m (44') | Medium Duty | 2.09 | 3.10 | 3.10 | 0.78 |
| M-9265 | 13.2 m (44') | Heavy Duty | 2.87 | 4.40 | 4.40 | 1.04 |

Note: The unfactored roof dead load is assumed to be 0.30 kPa on the roof surface.

The Canada Plan Service, a Canadian federal/provincial organization, promotes the transfer of technology through factsheets, design aids and construction drawings that show how to plan and build modern farm structures and equipment for Canadian agriculture.

For more information, contact your local provincial agricultural engineer or extension advisor.